WASHINGTON STATE DEPARTMENT OF ECOLOGY

April 2016

USE DESIGNATIONS FOR EROSION AND SEDIMENT CONTROL

For

Chitosan-Enhanced Sand Filtration using 1% HaloKlear® LiquiFloc™ chitosan acetate solution

Ecology's Decision:

Based on Ecology's review of HaloSoure Inc.'s (HI) application submissions and the findings by the Chemical Technical Review Committee (CTRC), Ecology is hereby issuing the following use designations for the Chitosan Enhanced Sand Filtration (CESF) technology for adequately controlling small particulate turbidity (clays, silt, etc.) in stormwater discharges at construction sites:

1. **General Use Level Designation for the CESF technology with the discharge of chitosan acetate treated water to retention systems capable of infiltrating all storms to the ground with no discharge to surface water. The operator shall base the design of the infiltration system on the criteria in Volume V of Ecology's most recent Stormwater Manual for Western Washington (SWMMWW) or Chapter 6 of the Stormwater Management Manual for Eastern Washington (SWMMEW). The operator shall strictly adhere to the design and operational criteria for the CESF specified in this document. You must keep records showing that you achieved total retention on site.**

2. **General Use Level Designation for the CESF technology with a discharge of chitosan acetate treated water from the sand filters to temporary holding ponds or basins then discharged to surface water (batch treatment). The operator shall strictly adhere to the design and operational criteria specified in this document.**

3. **General Use Level Designation for the CESF technology with the chitosan acetate treated discharges conveyed directly or indirectly to surface water (flow-through system). The operator may direct discharge to streams, lakes, and marine waters.**

This designation has no expiration date, but it may be amended or revoked by Ecology and is subject to all conditions contained in this use level designation.

Conditions Applicable to CESF under this designation

1. **Formal written approval from Ecology is required for the use of chemical treatment at each site. You must obtain written approval from the appropriate Ecology regional office.**

2. **This use level designation applies only to HaloKlear® LiquiFloc™ (1% chitosan acetate solution).**

3. **The chitosan dose rate for water entering the filters shall not exceed 1 mg/L HaloKlear® LiquiFloc™ (as chitosan by weight). Operators must record all calibration results simultaneously with the flowrates. Operators must keep all records on site.**

4. **The operator shall implement source control procedures to the maximum extent feasible to minimize the need for the use of additional chitosan acetate for the pretreatment of stormwater.**

5. **Operators may use additional HaloKlear® LiquiFloc™ (amounts greater than 1 mg/L chitosan by weight) to pretreat water that exceeds 600 NTU. Operators may use a portion of the 1 mg/L HaloKlear® LiquiFloc™ to pretreat water less than or equal to 600 NTU. Pretreatment must occur in a tank or basin dedicated to pretreatment. All pretreated water must enter the sand filters. Pretreated water must have no less than 50 NTU and no more than 600 NTU before final dosing. This will help ensure that free chitosan does not enter the CESF system. In addition, 1 mg/L HaloKlear® LiquiFloc™ (chitosan by weight) is sufficient to treat water in this range. The operator must continuously monitor water exiting the pretreatment tanks for turbidity. An automatic integrated turbidity sensor shall be located on the output from the pretreatment tanks or basins. This sensor will alert the operator when turbidity values fall outside of the 50 to 600 NTU range. If this occurs, operators can reroute the out of spec water to the untreated stormwater pond, shut the system down, or conduct additional residual chitosan tests. One of these actions must occur each time the alarm goes off. The operator must use jar tests to determine proper pretreatment dosing and proper treatment dosing.**

6. **This approval applies to discharges to streams, lakes, and marine water bodies. HaloSource provided additional aquatic toxicity testing for discharges to other waterbodies.**

7. **The operator shall conduct jar tests at startup to determine the dosage level of chitosan acetate solution. Additional jar tests will be conducted when influent turbidity changes by 20% or greater. The operator shall record jar test results**

in the daily operating log. If the results of the jar test indicate that the dose needs adjustment, the operator shall document the jar testing results and the indicated dose rate change in the daily operating log.

8. **During CESF operation, the operator shall continuously monitor water quality influent and effluent for pH, turbidity, and flow. For batch treatment systems, the operator must continuously monitor only water discharged from the batch treatment basins or tanks for pH, turbidity, and flow during discharge.**

9. **The operator shall continuously meter and record discharge flowrate. For batch treatment systems, the operator must continuously monitor only water discharged from the batch treatment basins or tanks for flowrate.**

10. **The operator shall monitor the effluent for residual chitosan or aquatic toxicity. If you monitor effluent for aquatic toxicity, you must use the most sensitive test reported in the intended use plan. If you monitor the effluent for residual chitosan, you must collect and analyze a discrete grab sample of homogeneous sand filter discharge within 30 minutes of the onset of operation and 2 hours after startup to confirm a discharge concentration below 0.2 ppm. You must repeat the test is to be repeated whenever there is a change in dosage, or a significant change in influent turbidity or flowrate (20% or greater). For batch treatment systems, you need to monitor only water discharged from the batch treatment basins or tanks. For batch treatment systems, you must collect and analyze an additional grab sample of the potential batch treatment discharge for aquatic toxicity or residual chitosan before any discharge from treatment basins or tanks can occur.**

11. **The operator shall complete an Operating Period Information Form for each operating period (system startup, operation, and shutdown). At a minimum, the form shall include the following:**
    - **A record of each recycle event**
    - **A record of each backwash event**
    - **Actions taken when a recycle event occurs**
    - **Actions taken when excessive backwashing is occurring**
    - **A record of pump calibration**
    - **A record of chitosan use for pretreatment**
    - **A record of chitosan dosage immediately prior to filters**
    - **A record of test results for chitosan residual in the effluent**

Weekly, the supervisor shall examine the forms completed the previous week. The supervisor shall sign each daily form indicating his review. The form shall document actions taken in response to any abnormal conditions observed by the operator.

12. **At all construction sites, at the end of the operating period, a delegated responsible person shall record their assessment of the operational efficiency of the CESF process, any upsets, the sand filter discharge chitosan**

concentrations, and any other relevant observations that relate to CESF proper operation. They must also certify the acceptability of the CESF discharge to surface water.

13. **Discharges from the CESF system shall not cause or contribute to receiving water quality violations and shall comply with the discharge requirements of the State of Washington Construction Stormwater General Permit, AKART, and local government requirements for turbidity and other applicable pollutants. The operator must use this designation document as the basis for Stormwater Pollution Prevention Plans (SWPPPs) for all construction projects where you plan to use chitosan treatment.**

14. **Discharges from the CESF system under these designations shall achieve performance goals of a maximum instantaneous discharge of 10 NTU turbidity and a discharge pH within a range of 6.5-8.5. These limits reduce interferences associated with the residual chitosan test.**

15. **The CESF facility contractor shall guarantee that the CESF system, when used as directed, will not produce treated water that exhibits aquatic toxicity caused by chitosan added as a treatment agent.**

16. **The CESF system operators shall trained technicians certified through an Ecology-approved training program that includes classroom and field instruction. The CESF operator must remain on-site during CESF operation. The technician must have the following minimum training requirements:**

Prerequisites:

- **Current certification as a Certified Erosion and Sediment Control Lead (CESCL), through an Ecology-approved CESCL training course.**
- **Fundamental knowledge of, high-pressure sand filter systems.**
- **Fundamental knowledge of water pumping and piping systems.**
- **Fundamental knowledge of stormwater discharge regulations for applicable region/locale.**
- **Fundamental knowledge of stormwater quality testing procedures and methods for parameters applicable to the region/locale.**

Classroom (8 hours)

- **Stormwater regulatory framework and requirements**
- **Stormwater treatment chemistry (chitosan, pH, coagulation, filtration, etc.)**
- **Stormwater treatability (how to do jar testing)**
- **Treatment system components and their operation**
- **Treatment system operation**
- **Troubleshooting**

In the field (32 hours)

- **Operating the treatment system**
- **Entering data in the system operations log**
- **Testing turbidity and pH**
- **Optimizing chitosan dose rate**

- **Water quality sampling and testing (turbidity and pH)**
- **Residual Chitosan Test**

17. The SWPPP is to include a field procedure, accepted by the Department of Ecology, for detecting residual chitosan in stormwater discharges sensitive to 0.2 ppm.

18. During the planning of the project, the operator must evaluate the adverse potential impacts on chitosan efficiency of the use of other erosion and sediment control practices.

<u>Design Criteria for CESF Systems:</u>

1. **You must design systems using the relevant portions of the most current versions of BMP C250 and BMP C251 of the SWMMWW and the SWMMEW. System design must consider downstream conveyance system integrity.**

2. **The facility shall employ a minimum of three (3) sand filter pods to ensure adequate backwashing capacity. The operator must discharge backwash slurry from the sand filters to a holding cell that is separate from the temporary storage cell for the incoming turbid stormwater. The overflow from the backwash slurry detention cell can overflow into the detention basin for the incoming turbid stormwater.**

3. **The operating flow rate shall not exceed 15 GPM per square foot of sand bed filtration area.**

4. **You must use filtration media approved in the Sand Filtration Treatment Facilities section (Volume V, Chapter 8) of the most recent Stormwater Management Manual for Western Washington in the filter pods. Minimum sand bed depth shall be 18 inches, underlain with a minimum of 6 inches of 1-inch crushed rock.**

5. **The CESF system shall include a flow-regulating valve on the input to and output of the sand filter. These regulating valves will reduce the maximum output of the pump as required and facilitate proper backwash.**

6. **The CESF system treated water output shall be equipped with an automatic integrated turbidity and pH sensor capable of shutting the system down if the output turbidity or pH exceeds preset values. You shall install an audible alarm and warning light on the treatment system to alert the operator in the event of a system failure.**

7. **You shall completely enclose the CESF control system (including metering pump, chitosan storage, and instrumentation) in a secure structure with locking door. You shall store the chitosan liquid concentrate in a non-corrosive storage tank. You shall install secondary containment on the Chitosan storage tank,**

metering pump, and tubing. There shall be an anti-siphon valve on the metering pump discharge tubing.

8. **The operator shall perform Chitosan injection with a LMI-brand C77 chemical metering pump, or equivalent. The operator must calibrate the metering pump within 15 minutes of the beginning of each operating period. You shall recalibrate the metering pump when a significant change occurs in either the flow or influent turbidity.**

Applicant: Dober Chemical Corporation
Tony Weisner
Senior Vice President

Applicant Address: 11230 Katherine's Crossing, Suite 101
Woodridge, IL 60517

Application Documents:

- Application for Conditional Short Term Use Designation for Chitosan Enhanced Sand Filtration, July 1, 2003, Peter Moon, P.E. and Paul Geisert, P.E., Price Moon Enterprises, Inc. for Natural Site Solutions, LLC. (NSS)
- Chitosan-Enhanced Sand Filtration. Engineering Report .with Addendum, NSS, May 15th, 2003
- Chitosan-Enhanced Sand Filtration System. Operation and Maintenance Manual. NSS, April 30, 2003.
- Toxicity Evaluations of Chitosan-based Products, Liqui-Floc and Gel-Floc: December 2002 and March 2003, AMEC Earth & Environmental Northwest Bioassay Laboratory, 5009 Pacific Hwy. East, Suite 2, Fife, WA 98424. (253) 922-4296.
- Understanding the Freshwater Aquatic Toxicity of Chitosan When Used in Engineered Sand Filtration Stormwater Treatment Systems; March 27, 2003. John Macpherson, CPESC, NSS.
- Analytical Testing Demonstrating the Inability of a Solution of Chitosan Acetate to Penetrate a Model Sand Filter; John Macpherson, NSS.
- Quality Assurance Project Plan, Third Version, January 12, 2004, John MacPherson, NSS
- Technical Engineering Evaluation Report (TEER) For The Chitosan-Enhanced Sand Filtration Technology for Flow-Through Operations, Gary Minton, February 28, 2006
- Rainbow trout (Oncorhynchus mykiss) Chronic Toxicity Screening of Stormwater Treated by Chitosan Enhanced Sand Filtration Flow-Through System – Redmond, Washington, ECO-Endeavors, Inc, June 2, 3004
- Toxicity testing for Liqui-Floc: Final Report, Nautilus Environmental, LLC, September 30, 2004
- Colorimetric Determination of Residual Chitosan in Treated Stormwater: Field Test, Natural Site Solutions, LLC, July, 2004
- Certification of Residual Chitosan Test by AM TEST Laboratories, October 27, 2005

- Chitosan-Enhanced Sand Filtration System Using HaloKlear™ LiquiFloc™ Operations and Maintenance Manual, HaloSource, February, 2007
- Expanded Approval of CESF Treatment Using Liquifloc 1%, Department of Ecology, September 19, 2013

Applicant's Use Level Request:

General use level designation for the operation of chitosan-enhanced sand filtration (CESF) technology for the reduction of turbidity in construction site stormwater.

Applicant's Performance Claims:

For construction site stormwater runoff with a turbidity of less than 600 NTU (influent), a properly engineered and deployed *Chitosan-Enhanced Sand Filtration System* will remove greater than 95% of the turbidity, producing effluent that will consistently meet the State surface water discharge standards.

Chemical Technical Review Committee (CTRC) Recommendation:

The CTRC finds sufficient evidence to recommend to Ecology to grant a GULD for flow-through treatment that can remove turbidity from stormwater at construction sites within acceptable limits for chitosan enhanced sand filtration using HaloKlear® LiquiFloc™ 1% chitosan acetate.

Findings of Fact:

1. A CESF system charged with #30 crushed silica sand has demonstrated the ability to reduce turbidity caused by the disturbance of sediment on construction sites by 97.44 percent (overall average) when operated at a flowrate of approximately 15 gallons per minute per square foot of filtration surface area. This translates to a flowrate of approximately 500 GPM when using a 48-inch diameter, 4-pod sand filter module. HaloSource monitored over 1500 operating periods over a two-year period. Data from these operating periods show that discharge graphs were always below 10 NTU. Any discharge that exceeded 10 NTU was recycled. Recycle rates ranged from 4-17%.

2. Influent turbidity levels above 600 NTU demonstrated the potential to cause a slow degradation of the turbidity removal performance by the system resulting in eventual system failure. CESF systems shall be limited to influent turbidity levels of 600 NTU or less. Turbidity levels above 600 NTU shall be allowed additional settlement time or be pretreated.

3. Water with a pH range outside the CESF treatment window of 6.5 to 8.5 shall be pretreated to achieve this range. This application did not cover the pretreatment process.

4. In the CESF treatment systems that have been constructed and operated to date, we have observed no aquatic toxicity in the treated filtrate.

5. The chitosan acetate polymer component, used for water treatment, is non-toxic to humans and other mammals, which makes it somewhat unique in the universe of treatment agents. Chitosan acetate does, however, exhibit toxicity to rainbow trout. Therefore, you should use Chitosan acetate at a maximum dose rate of 1 mg/L as chitosan acetate by weight as a conservative measure to ensure no possibility of toxicity to rainbow trout in receiving water.

6. HaloSource provided a design/operation/maintenance manual, which includes information on selecting, sizing, assembling, operating and maintaining a CESF system.

7. NSS and HaloSource provided a significant amount of aquatic toxicity data demonstrating that they expect the discharge residual of the chitosan acetate polymer to be within toxicity levels acceptable to Ecology when used as directed.

8. NSS and HaloSource provided other supporting information including system limitations and constraints, system specifications and warranty information.

Description of the Technology:

Chitosan-enhanced sand filtration (CESF) is a stand-alone construction site water treatment technology, which is comprised of four basic components:

- Stormwater transfer pump
- Chitosan addition
- Pressurized multi-pod sand filtration
- Interconnecting treatment system piping

You can use CESF as a flow-through stormwater treatment technology that utilizes chitosan, a natural biopolymer, in conjunction with pressurized sand filtration to remove turbidity (suspended sediment). Each treatment system is designed and installed to be operated on an as need basis, pumping water from a retention basin whenever the water level of the retention basin is high enough to warrant processing. When someone transfers stormwater from the retention basin to the sand filtration unit, they introduce chitosan to stormwater to coagulate suspended solids producing larger particles, which they retain within a sand filter. The filtration systems are equipped with automatic backwash systems, which will backwash the collected sediment from the individual filter pods as necessary to maintain the hydraulic capacity of the filtration media. This feature allows the treatment system to operate on a continuous flow-through basis. A link to a diagram of the system is included here:

Recommended Research and Development

Ecology encourages HaloSource, Inc. to pursue continuous improvements to the CESF system. To that end, Ecology recommends the following actions:

- Further field testing is necessary to determine the optimum dose rate for various influent concentrations.
- Conduct further research to create a more reliable residual chitosan test. Develop a test that quantifies chitosan concentrations.
- Determine how different soil types affect chitosan treatment.
- Determine aquatic threshold for marine species.

Contact Information:

Applicant: Tony Weisner, Senior Vice-President
Office: 630-410-7300
Email: tweisner@dobergroup.com

Applicant Website: www.dobergroup.com

Ecology web link: http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html

Ecology: Douglas C. Howie, P.E.
Water Quality Program
(360) 407-6444
douglas.howie@ecy.wa.gov

Revision History

Date	Revision
April 2008	Original Draft use-level-designation document
August 2010	Modified contact information
September 2013	Added ability to discharge to lakes and marine waters
March 2015	Revised Contact Information
December 2015	Revised name from StormKlear to HaloKlear
April 2016	Revised contact information following sale of business by HaloKlear

EXPANDED APPROVAL OF CESF TREATMENT USING LIQUIFLOC 1%
September 19, 2013

The chitosan-enhanced sand filtration (CESF) stormwater treatment system using HaloKlear LiquiFloc™ containing 1% chitosan acetate has been granted General Use Level Designation in Washington State. Natural Site Solutions, LLC submitted the original Intended Use Plan dated November 18, 2004 to describe how the LiquiFloc concentration will be kept below its toxic threshold to key species. The intended use plan describes how a CESF system is operated so that the chitosan dose concentration is always below the most sensitive toxic threshold. After being dosed to a concentration that is below the toxic threshold, the chitosan concentration in the stormwater will be reduced further by binding to suspended solids and then binding to the sand filter before being discharged.

The following list includes the toxicity tests and species that were performed and has added the results from the mysid 7-day survival and growth test. The approval is now expanded to include discharges to any surface water in the state, including lakes and marine waters.

Toxicity Tests and Results

Toxicity Testing Results for LiquiFloc 1% (as mg/L of chitosan acetate)

Test	**Endpoint**	**EC_{50} (mg/L)**	**EC_{25} (mg/L)**
Daphnia pulex 48-hr acute	survival	23.2	18.3
rainbow trout 96-hr acute	survival	1.73	1.28
fathead minnow 96-hr acute	survival	6.42	1.26
rainbow trout 7-day survival & growth	survival	1.54	1.21
	weight	> 2.5	> 2.5
fathead minnow 7-day survival & growth	survival	> 10	9.32
	weight	> 10	6.88
rainbow trout embryo viability	viability	> 10	> 10
fathead minnow embryo-larval survival & teratogenicity	survival	> 10	> 10
	development	10	10
mysid 7-day survival & growth	survival	> 4	> 4
	weight	> 4	0.98

Intended Discharge Concentration

The intended discharge concentration is conservatively estimated to be 0.1 mg/L. The Residual Chitosan Field Screening Test has been performed hundreds of times on treatment system effluent. The detection limit of this procedure is 0.1 mg/L and no chitosan has ever been detected in effluent. In addition, clean water containing 2 mg/L of chitosan was passed through a sand filter in a bench scale test and no chitosan was detected in the filtrate using a procedure with a detection limit of 0.03 mg/L.

Safety Margin for the Most Sensitive Response (mysid weight)

The toxic thresholds are all greater than three times the intended discharge concentrations. Therefore, the safety margins are not considered to be narrow. In addition, 14-day flow-through toxicity testing with rainbow trout was done in 2004 at a construction site in Redmond, Washington with the result of 100% survival. No confidence building period of flow-through or *in-situ* toxicity testing is needed. The data support the future approval of chitosan concentrations above 1.06 mg/L in very turbid stormwater prior to sand filtration without needing to change the goal of the intended use plan of keeping the dose concentration below the toxic threshold.

Maintenance of Safety Margin

Chitosan acetate can effectively treat stormwater turbidity up to 600 NTU without using a concentration above 1.06 mg/L. 1.06 mg/L chitosan is below its toxic threshold of 1.21 mg/L in clear water. In addition, chitosan will be removed from solution by binding to solids and by being withheld in the sand filter. The safety margin will certainly be maintained if the treatment concentration is kept to 1.06 mg/L or below. Any mechanical failure of the positive displacement metering pump will immediately cause a reduction in LiquiFloc dosing so pump failure is only a problem for treatment effectiveness and not safety margin maintenance.

The following dose rate table shall be used to ensure both treatment plant effectiveness and a chitosan concentration below 1.06 mg/L prior to sand filtration.

Dose Rate Table for LiquiFloc (1% chitosan acetate) Based on Flow and Turbidity

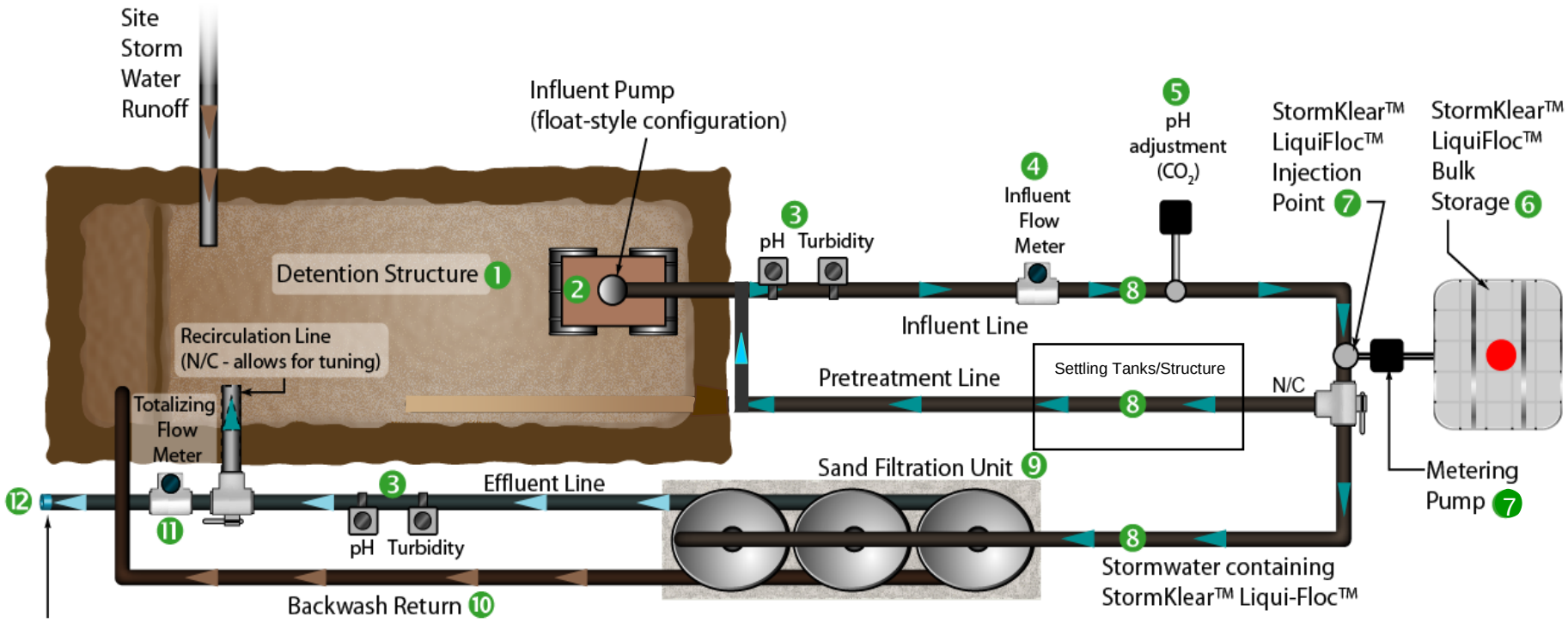
turbidity	stormwater flow rate	LiquiFloc dose rate	chitosan concentration
50 - 200 NTU	200 gpm	20 ml/min or 0.32 gph	0.26 mg/L
	300 gpm	30 ml/min or 0.48 gph	
	400 gpm	40 ml/min or 0.64 gph	
	500 gpm	50 ml/min or 0.8 gph	
	600 gpm	60 ml/min or 0.96 gph	
	700 gpm	70 ml/min or 1.11 gph	
200 - 400 NTU	200 gpm	40 ml/min or 0.64 gph	0.53 mg/L
	300 gpm	60 ml/min or 0.96 gph	
	400 gpm	80 ml/min or 1.27 gph	
	500 gpm	100 ml/min or 1.6 gph	
	600 gpm	120 ml/min or 1.91 gph	
	700 gpm	140 ml/min or 2.23 gph	
400 - 600 NTU	200 gpm	80 ml/min or 1.27 gph	1.06 mg/L
	300 gpm	120 ml/min or 1.91 gph	
	400 gpm	160 ml/min or 2.54 gph	
	500 gpm	200 ml/min or 3.17 gph	
	600 gpm	240 ml/min or 3.81 gph	
	700 gpm	280 ml/min or 4.45 gph	

Checking formula:
chitosan concentration in mg/L = (ml/min LiquiFloc x 0.01 x 1 g/ml x 1000 mg/g)/system flow rate in liters/min
liters/min = gpm x 3.78 liters/gal

Safety Margin Checklist

- Only HaloKlear LiquiFloc™ containing 1% chitosan acetate shall be used.
- The metering pump shall be calibrated using a calibration cylinder at startup and every time that the LiquiFloc dose rate needs changed. The calibration shall be recorded in the log. The stroke frequency shall be set as high as possible and the stroke length adjusted to provide the correct dosing.
- The system flow rate and the turbidity of both influent and effluent shall be measured hourly and recorded in the log.
- No chitosan-treated water shall be discharged to surface water without first being sand-filtered.
- Secondary containment for the LiquiFloc storage container and the metering pump shall be at least equal to the volume of the storage container.
- Spill adsorbent material shall be readily available to immobilize any spill of LiquiFloc during handling.
- If the treatment system is located less than 50 feet from surface water, a 1-foot high earthen berm shall be constructed and maintained down-gradient as additional spill containment.
- The occasional use of the Residual Chitosan Field Screening Test to confirm a discharge concentration below 0.1 is encouraged in order to further build confidence in CESF system safety.

Schematic Diagram of CESF System



Note: Pretreatment line shown is conceptual, additional equipment/piping may be required.
If you use pretreatment dosing, you can read water quality after settling at the influent pH and turbidity location.

Rev2.1